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MODELING AND EVALUATING EMOTIONS IMPACT ON COGNITION

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**14. ABSTRACT**

The objective of this project was to make advances in modeling the relationship between emotion and cognition. The researchers proposed to use computational models to concretize psychological theories concerning the relationship between emotion, cognition and behavior, and to collect a body of human performance data with which to validate and inform this process. Major accomplishments included the creation of an experimental testbed to study emotion influenced decision making, and a series of experimental studies using this testbed to test specific hypotheses produces by a computational model of emotion-influenced decision-making. Results of these studies lend support to the validity of this computational model. A series of studies investigate the accuracy of competing computational models of emotion in predicting the intensity of human emotional responses in naturalistic emotion-eliciting situations. The results find clear differences in models' ability to forecast human emotional responses, and provide guidance on how to develop more accurate models of human emotion. A series of studies also investigated how people's beliefs, desires and intentions change in response to positively and negatively valenced emotional situations. We examined three key kinds of coping, Wishful Thinkin

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Attachment A

**Grant Number:** AFOSR FA9550-06-1-0206
**Project Title:** Modeling and Evaluating Emotion's Impact on Cognition
**Start Date of Project: March 1, 2006**
**End Date of Project: April 31, 2009**
**ICT Technical Point of Contact: Jonathan Gratch**

# Final Technical Report

**Proposal Title(s):** Modeling and Evaluating Emotion's Impact on Cognition

**Technical Point of Contact: Jonathan Gratch, 310-440-0306, gratch@ict.usc.edu**

**Date: August 11, 2000**

**Project Goals:** The objective of this project was to make advances in modeling the relationship between emotion and cognition. In terms of basic science, we proposed to use computational models to concretize psychological theories concerning the relationship between emotion, cognition and behavior, and to collect a body of human performance data with which to validate and inform this process. In terms of engineering, we proposed to construct a problem solving test bed to which will allow direct comparisons between human and simulated problem solving performance.

**Primary Accomplishments:** Project plans are largely proceeding as planned. Accomplishments include:

- Created a problem solving test bed based to elicit and measure human emotional responses and behavior tendencies within the context of a two-player board game (based on the board game Battleship, by Milton Bradley).
- Modeled this situation within EMA, a computational model of human emotional decision making. This model forms predictions of likely emotional reactions and coping strategies based on an individual's beliefs, desires and intentions about a situation, as well as how these reactions and strategies change over time. We then used the model to generate several specific predictions about the nature and intensity of human emotional responses to in-game events as well as specific predictions on how subjects would likely cope with these responses through alterations in their beliefs, desires and intentions.
- Developed an experimental methodology to test these predictions by assessing subjects' emotional responses in response to carefully scripted behaviors of a confederate during game play.
- Developed a general experimental test bed to study how different communication protocols influences decision making in multi-player tasks. These protocols include face-to-face communication, communication via video, via generated avatars, via audio, or via text. Test bed is designed to capture player game play and a variety of biometrics including vocal features, head movements and (to a limited extent) facial expressions.
- Carried out a series of experimental investigations to assess the validity of predictions made by EMA. Predictions were largely supported by data, with some exceptions that will motivate future study.

**Major Empirical Findings:** (details can be found in the first 2 publications listed below)

- A series of studies investigate the accuracy of competing computational models of emotion in predicting the intensity of human emotional responses in naturalistic emotion-eliciting situations. The results find clear differences in models' ability to forecast human emotional responses, and provide guidance on how to develop more accurate models of human emotion. Specifically, expected utility provides an excellent fit for modeling the intensity of the prospect-based emotions (i.e. hope and fear). The fit for both outcome-based emotions (i.e. joy and sadness) is best

approximated by a hybrid model that falls somewhere between an expected-utility and threshold model. Other intensity models proposed in the literature did not fare well. The expectation-change model was worse than a degenerate model that ignores probability and utility. The additive model performed better than the expectation-change model but was dominated by expected utility. The results have clear implications for computational models of how human's construe emotionally-charged situations.

- A series of studies investigated how people's beliefs, desires and intentions change in response to positively and negatively valenced emotional situations. We examined three key kinds of coping, Wishful Thinking, Resignation and Distancing that impact an individual's beliefs, intentions and desires, and compare these coping responses to related work in the attitude change literature. We assessed hypotheses derived from the EMA computational model of emotion against the behavior of human subjects playing a competitive board game, using monetary gains and losses to induce emotion and coping. Subject's appraisals, emotional state and coping responses were indexed at key points throughout a game, revealing a pattern of subject's altering their beliefs, desires and intentions as the game unfolds. The results clearly support several of the hypotheses on coping responses but also identified (a) extensions to how EMA models Wishful Thinking as well as (b) individual differences in subject's coping responses. The results have implications for computational models of emotion's influence on human belief-change and decision-making.

**Staff supported under grant:** The following personal were supported under the period of performance of the grant

- Faculty:
  - Jonathan Gratch
  - Stacy Marsella
- Postdocs
  - Wendy Treynor
  - Ning Wang
- Graduate Research Assistants
  - Anya Okhmatovskaia
- Undergraduate Research Assistants:
  - Jeff Magers
  - Erin Margolis
  - Emily Salans
- Research Staff
  - Jamison Moore
  - Brooke Stankovic

**Grant related publications and invited talks:**

- Jonathan Gratch, Stacy Marsella, Ning Wang. Assessing the validity of appraisal-based models of emotion in agent-based systems. *International Conference on Affective Computing and Intelligent Interaction,* Amsterdam, 2009
- Stacy Marsella, Jonathan Gratch, Ning Wang. Assessing the validity of an computational model of emotion-focused coping. *International Conference on Affective Computing and Intelligent Interaction,* Amsterdam, 2009

- Jonathan Gratch, Stacy Marsella and Paolo Petta, "Modeling the Antecedents and Consequences of Emotion," *Journal of Cognitive Systems Research,* 10(1), 2009, pp. 1-5.
- Stacy Marsella and Jonathan Gratch, "EMA: A Model of Emotional Dynamics," *Journal of Cognitive Systems Research,* 10(1), 2009, pp. 70-90.
- Paul Thagard, Peter Ditto, Jonathan Gratch, Stacy Marsella and Drew Westen. Emotional Cognition in the Real World. *Proceedings of the Twenty-Ninth Annual Meeting of the Cognitive Science Society*. Nashville, TN: Lawrence Erlbaum Associates. 2007
- Wenji Mao and Jonathan Gratch. Modeling social inference in virtual agents. *Journal of Artificial Intelligence and Society, special issue on social intelligence and design,* 24(1), 2009, pp. 5-11
- Paolo Petta and Jonathan Gratch. Computational Models of Emotion. *Oxford Companion on Affective Sciences.* Sander and Scherer (ed.). Oxford University Press.
- Mei Si, Stacy C. Marsella, David Pynadath. Modeling Appraisal in Theory of Mind Reasoning. IVA 2008: 334-347
- Invited panel organizer and speaker, International Conference on Human-robot Interaction, March 2009
- Invited panel organizer and speaker, National Communications Association, San Diego, November 2008
- Invited speaker: Carnegie Mellon University, Human Computer Interaction Institute, Seminar Speaker, October, 2008
- Keynote speaker, International Symposium on Ubiquitous Virtual Reality, July 2008
- Invited speaker: Greifswald University, Department of Psychology, July 2008
- Invited presentation: National Academy of Sciences, Committee on Opportunities in Neuroscience for Future Army Applications, February 2008.
- Invited speaker: USC Conference on Emotion, Decision Making, and the Brain, August 2007
- Invited presentation: Simulating Emotion and Nonverbal Behavior with Actors and Agents. National Academy of Sciences, Board on Army Science and Technology, Washington D.C., December 2006.
- Distinguished lecture series: Emotion in Human-Agent Interactions. Technology and Social Behavior Speaker Series, Northwestern University, November, 2006

abstract

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